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MB-339CD Aircraft Development
COTS Integration in a Modern Avionics Architecture

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1. INTRODUCTION

Obsolescence of electromechanical instruments and navigation sensors is one of the main reasons for new avionics development in military training aircraft upgrade programs.
The growing requirements for advanced trainers in the role of lead-in-fighter aircraft push the development of integrated avionics system where cockpit displays, mission computer, solid-state navigation sensors, communication transceivers and flight data recorders are extensively employed.

The use of COTS (Commercial Of The Shelf) solutions allows to mitigate components obsolescence and to meet the new operational requirements at an affordable cost with reasonable development risk.

The purpose of this paper is to provide an overview of how these concepts have been applied in the development of an innovative, modular and reliable avionics system.

The latest version of the proven MB-339 twin seat jet powered advanced trainer employs a modern state-of-the-art avionics architecture based on standard bus interface (i.e., MIL-STD-1553 and ARINC 429), capable to easily integrate COTS equipment.
The system exhibits a full glass cockpit with three identical and interchangeable Multifunction Displays, Head-up Display and independent get-home instrumentation for back-up flight data presentation: all the cockpit displays use COTS active matrix full colour high resolution LCD's.

COTS solutions are applied at hardware level in computer processing, interface and memory devices, providing state-of-the-art high performance digital technology solutions.
Radio navigation equipment, air data computer and an embedded inertial-GPS platform are employed as proven, off-the-shelf and fully qualified military equipment.

The paper highlights the advantages gained by the employment of COTS solutions in a modern, flexible and expandable avionics architecture. In the paper, the equipment is deliberately described in general terms, omitting any manufacturer reference.

2. MB-339CD AVIONICS

2.1 General

The Aermacchi MB-339CD aircraft (Fig. 1) is a single engine, tandem seat jet trainer designed for advanced and lead-in-fighter training in order to allow pilot's conversion to the latest generation of operational aircraft.

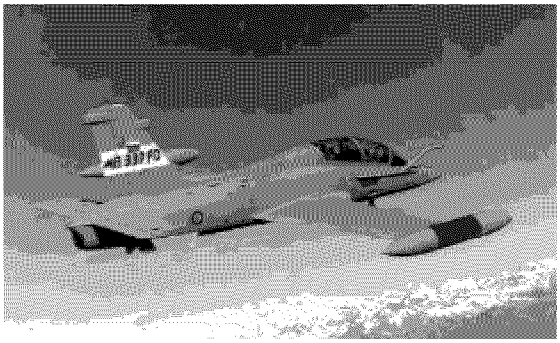

Figure 1. MB-339CD Aircraft.

The aircraft was designed, developed and tested in the middle of the 90's and is currently in service with the Italian Air Force. The first flight was performed on April 1996 while the Final Operational Capability (FOC) was reached on October 1998; an improved version of the aircraft, with additional capabilities, will be delivered on December 2001.

The MB-339CD aircraft design is based on the proven airframe structure, engine and general systems (i.e., fuel, hydraulic, electrical, flight controls and landing gear) fully qualified on the MB-339A model, while a new avionics system is fitted in order to enable training with modern operational techniques, including use of an Head-up Display (HUD), Hands On Throttle and Stick (HOTAS), and Multifunction Displays (MFD's), enhancing mission effectiveness and aircraft survivability (Fig. 2).

Paper presented at the RTO SCI Symposium on "Strategies to Mitigate Obsolescence in Defense Systems Using Commercial Components", held in Budapest, Hungary, 23-25 October 2000, and published in RTO MP-072.

Thanks to the avionics updating, the MB-339CD fills the gap between traditional trainers and new combat aircraft.
The MB-339CD avionics is based on a modern architecture using digital data buses as mean of on-board information exchange between sensors, computers and cockpit displays.

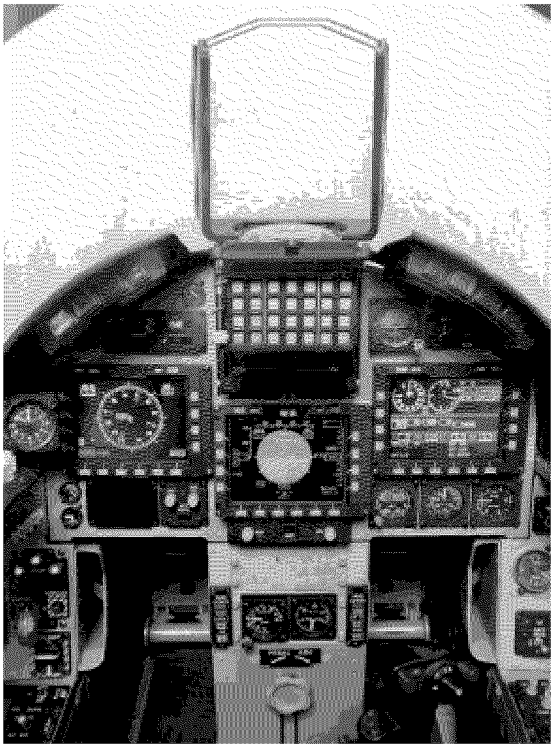

Fig. 2. MB-339CD Cockpit Layout.

The installed navigation sensors, processing equipment and electronic displays not only exhibit high performances in terms of accuracy, growth potential and man-machine interface, but also show improved reliability reducing in service maintenance costs.

This section provides a description of the aircraft sensors, computers, controls and displays, merged in a fully integrated Navigation/Attack system.

2.2 Avionics Architecture

The main components of the MB-339CD avionics are the following:

Sensors

- Embedded GPS-Inertial (EGI) platform
- Air Data Computer with associated Pitot/Static ports and Total Temperature Sensor (TTS)
- Angle of Attack and Angle of Sideslip transducers
- Radio Navigation systems including VOR/ILS, TACAN and ADF
- Radar Altimeter

Computers

- Mission Processor (MP)
- Data Transfer System with embedded Digital Map Generator (DMG)
- Engine Instrument and Crew Alerting System (EICAS) Data Acquisition Box (EDAB)
- Stores Management System (SMS)

Recorders

- Flight Data Recorder (FDR) with Crash Survivable Memory Unit (CSMU)
- Video Cassette Recorder (VCR)

Controls and Displays

- Head-up Displays (HUD) with embedded Data Entry Panel (DEP)
- Multifunction Displays (MFD)
- HOTAS controls
- Heading/Course and Baro/Altitude rotary controls

These components are interconnected, directly or through adequate interfaces, by a MIL-STD-1553 dual redundant data bus called Avionics Bus (Fig. 3).
The Avionics Bus is mainly controlled by the Mission Processor which acts as the primary Bus Controller; in the event of a critical Mission Processor failure, the EGI system is able to provide back-up bus controller capability assuring complete redundancy.

Several equipment such as EDAB, MP, FDR include analog, discrete, video and digital interfaces in order to allow the acquisition of the parameters provided by aircraft devices (general systems transducers, HOTAS and rotary controls) and to allow the integration of equipment which have non-1553 interface.

The system architecture is characterised by a distributed processing capability which allows a rationale and simple allocation of the system functions: the EGI and ADC provide the navigation parameters directly used by the primary flight displays, the EDAB is based on two fully redundant and independent electronic circuits capable to provide in digital form the parameters acquired by the general systems and the MFD include 1553 interface and graphic processing, to autonomously generate the symbology based on the information available on the Avionics Bus.

With these important characteristics the required system redundancy is obtained without duplication of the central processing and symbology generation. The overall result is a simple and reliable architecture.

The high level of flexibility of the avionics system, coupled with the considerable computing capability of the installed computers, allows for a remarkable growth potential such as: self-protection systems (including a

Radar Warning Receiver, a Chaff and Flares Dispenser and a pod mounted active ECM), a Forward Looking IR (FLIR) system, a pod mounted Reconnaissance (RECCE) system, a rangless GPS-based Air Combat Manoeuvring Instrumentation (ACMI) system, and embedded sensors (Radar/RWR) simulation capability.

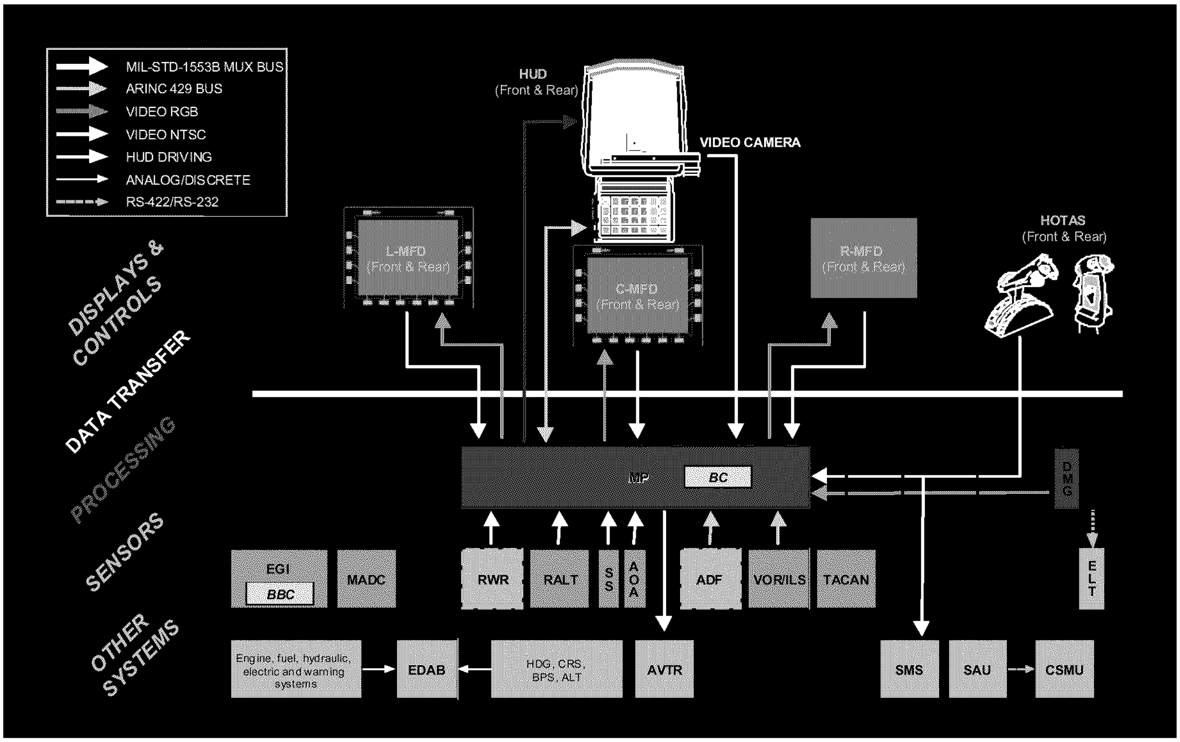

Figure 3. MB-339CD Avionics Architecture.

2.3 Sensors

The **Embedded GPS Inertial** (EGI) platform is a self-contained unit consisting of three Ring Laser Gyros, three solid-state accelerometers and associated electronics capable to guarantee accurate inertial navigation; embedded in the EGI is a tightly coupled GPS receiver module with 6 channels and P(Y) code capability which uses pseudo-range and pseudo-range rate satellite data.

The EGI supplies the navigation/attack system with accurate information related to the aircraft attitude, position, velocities and accelerations: roll and pitch angles, roll, pitch and yaw rates, magnetic and true heading, ground speed, aircraft body axes speeds and accelerations, present position, wind data, steerpoint data, and time data referred to the GPS.

The demonstrated EGI performances are the following:

- Position accuracy (CEP) pure inertial: < 0.8 NM/h;
- Position accuracy (CEP) blended: < 100 m (SPS);
- Velocity accuracy (rms) pure inertial: < 1.0 m/s;
- Velocity accuracy (rms) blended: < 0.03 m/s.

The provided data are always the best available solution obtained by filtering the inertial and GPS data through a Kalman filter. This allows reduction of the Mission Processor workload.

The GPS receiver can work in the Standard Positioning Service or in the Precise Positioning Service mode.
Thanks to the GPS integration, the EGI can be commanded to align on ground and in flight with a nominal alignment time of 4 minutes.

The **Air Data Computer** (ADC) with associated Pitot/Static ports and Total Temperature Sensor (TTS) includes extremely accurate pneumatic transducers and, thanks to a powerful computer, is able to provide in digital form the most important air data parameters: total and static pressure, altitude, vertical velocity, baro corrected altitude, indicated and true airspeed, Mach number, maximum allowable airspeed, and outside total temperature.

The ADC guarantees the following performances:

- Pressure Altitude accuracy ± 7 ft (sea level)
- Indicated Airspeed accuracy ± 0.5 kts @ 300 kts
- Temperature accuracy ± 0.5°C

The unit design is characterised by ultra compact and light box (< 0.9 kg) and extremely reduced power requirements (6 W @ 28 Vdc).

The **Angle of Attack** and **Angle of Sideslip** transducers are directly connected to the Mission Processor, which includes the Analog to Digital converter to acquire and convert the parameters.

The **Radio Navigation** system is based on three equipment: VOR/ILS/MB, TACAN and ADF.

The **VOR/ILS/MB** unit is a fully digital VO/LOC, Glideslope (GS) and Marker Beacon receiver, providing both Commercial Standard Digital Bus (CSDB) and ARINC 429 interfaces. The VOR/ILS/MB operates with a frequency control panel and three antennas; it uses digital techniques to read serial input data provided by the frequency control panel, to compute navigation situation and to generate serial data outputs including VOR Bearing, ILS Lateral and Vertical deviations, MB annunciators. The unit design guarantees FM immunity and software verification according to DO-178A, lev. 1.

The **TACAN** receiver-transmitter is a microprocessor-controlled unit operating with two antennas and remote control panel. It outputs bearing, slant range, time to station, range rate and Morse code identification from a standard TACAN ground station. The equipment provides also an air-to-air operational mode for aircraft ranging, bearing and identification reception from equipped aircraft; it includes the complete provision for DME-P function.
The units operates with all 126 X channels and 126 Y channels providing an RF peak power of 750 watts.

The **ADF** (provision) is a microprocessor controlled receiver providing relative bearing between aircraft and the selected ground station. The receiver operates with a frequency control panel and a dedicated antenna. The output data is provided through a digital ARINC-429 data bus.

The **Radar Altimeter** (Radalt) is a solid-state system performing aircraft height measurements with the following characteristics:

- Height accuracy	± 3 ft
- Altitude range	0 to 5000 ft
- Attitude (pitch/roll) range	± 45°

It generates analog signals acquired and processed by the Mission Processor to provide height digital data to be displayed on MFD and HUD; the output data are also used by the MP to provide a low-altitude warning through the Audio Warning Generator.

2.4 Processing Equipment

The **Mission Processor** is the heart of the avionics system since it performs essential functions like Avionics Bus control, Head-up Display symbology generation, HOTAS interface and Navigation/Attack computation.

The equipment is a high performance, 12 slots, full military qualified computer; it is based on a powerful RISC CPU and characterised by a modular design exhibiting the following main features:

- CPU	RISC 3081, 12 MIPS;
- Memory	2 Mbytes RAM, 8 Mbytes FLASH, 128 Kbytes EEPROM;
- Interfaces	MIL 1553, ARINC 429, analog, discrete, video;
- Application Software	ADA language.

The full development phase of the Operational Flight Programme (OFP), including software specifications, coding, verification and validation, has been performed by Aermacchi, assuring a complete in-house management capability of the avionics system.
Under OFP control, the MP is capable to perform the following functions:

- primary 1553 bus controller;
- HUD symbol generation;
- HUD Data Entry Panel interface;
- ARINC 429 interface for VOR/ILS/MB and ADF receivers;
- analog and discrete interface to Radalt, HOTAS, Angle of Attack and Sideslip transducers;
- video interface and switching for HUD Video Camera, MFD's and Video Tape Recorder;
- management of control inputs from MFD's, HOTAS and Data Entry Panel;
- navigation computation including data base management;
- flight director and altitude alerter processing;
- weapon aiming computation.

The **Data Transfer System**, directly connected to the Avionics Bus, allows to update the mission data and to record the flight history data used for mission debriefing purposes. The DTS also includes the Digital Map Generator, which provides raster and vector colour moving map capability.

The equipment consists of a receptacle unit and a removable cartridge, reprogrammable on ground using a Mission Planning and Debriefing Station (MPDS) based on a Personal Computer.
Key feature of the equipment is that the mass memory required by both cartographic files and mission data is fitted in the cartridge, allowing direct access by the map generator and immediate replacement by the pilot.
The unit output is an RGB video signal directly driving the Multifunction Displays through the Mission Processor, while the cartridge uses solid state memory devices with expansible memory capacity: the present configuration is 1 Gbyte Flash covering 1.000.000 km^2 (1:100K) map data.
The in-flight available functions include:

- heading-up or north-up orientation
- scale and zoom selection

- scrolling, freeze and declutter capabilities
- DTED information management including safety height indication
- navigation overlay management
- tactical overlay management

The Engine Instrument and Crew Alerting System (EICAS) Data Acquisition Box (**EDAB**) is the main interface between the aircraft general systems and avionics. It acquires, computes and transmits in digital form all the parameters to be presented on the cockpit displays, relevant to:

- Engine → RPM, Jet Pipe Temperature, Oil Pressure, Fuel Flow
- Fuel → tanks fuel quantity
- Hydraulic → main and emergency pressure
- Electric → generators load
- Anti-ice → heaters status

In addition, the EDAB processes all the information needed to produce visual caution indication displayed on the MFD's and activates the relevant aural messages provided by the Audio Warning Generator.
The equipment is characterised by a fully redundant architecture: two independent sections performs all the above mentioned functions assuring that no single failure leads to the loss of the relevant indication. All electronic circuits and devices, starting from the anolog/discrete input to the 1553 transceiver, are duplicated providing high reliability and fault tolerant operation.

The **Stores Management System** is fully integrated in the avionics system using the MFD as the main pilot interface for display and selection of the stores carried under the wings. In addition a weapon inventory panel is provided to the ground crew in order to enter the armament stores configuration and to check system serviceability. The system includes independent circuits for stores release/launching/firing and emergency jettison operations and, due to the trainer role of the aircraft, its hardware design is optimised to reach the maximum level of operational safety.

The SMS allows the pilot to operate in the following modes:

- Continuously Computed Impact Point;
- Continuously Computed Release Point;
- Lead computed Optical Sight;
- Continuously Computed Impact Line;
- Air-to-Air Missile;
- Dogfight.

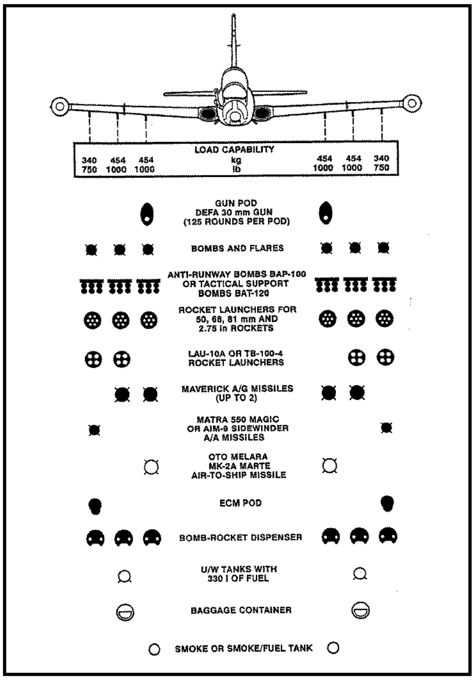

Figure 4. External Loads Capability.

Although light and compact units are installed in the aircraft, the SMS exhibits a wide weapons and external load capability as shown in Fig. 4.

2.5 Recording Equipment

The recording system collects all the information useful for pilot mission debriefing, maintenance trouble shooting and, in case of accident, reconstruction of the last period of flight. The system includes: a Video Recorder, a Flight Data Recorder and an Airborne Strain Counter.

The **Video Tape Recorder** (VTR) records, according to pilot selection, the images displayed on one the front cockpit MFD's or the HUD symbology superimposed on the external world as seen by the HUD Video Camera. In addition to the colour images, the VTR records the communications between the two pilots and between the aircraft and the ground stations.
The VTR uses standard Hi-8mm cassette providing access to commercially available playback units and videocassettes.

The **Flight Data Recorder** (FDR) system includes a Signal Acquisition Unit (SAU) and a Crash Survivable Memory Unit (CSMU), and is used for maintenance and post-accident analysis purposes.
The SAU is capable of receiving a combination of analog, discrete and digital (1153) parameters which are converted, compressed and stored in the embedded memory unit; the same parameters are transmitted to the CSMU where they are stored in a solid-state, non-volatile and protected memory.

The CSMU is designed to withstand stringent mishap conditions including fire temperature, mechanical shock and penetration.
All the data collected by the FDR are stored at lower sample rate in the cartridge of the Data Transfer System allowing immediate data availability for mission debriefing and maintenance.

The **Airborne Strain Counter** allows structural elements monitoring in order to determine the fatigue life of the airframe under real usage.
The microprocessor controlled equipment features the acquisition of seven strain gauges fitted in the most significant points of the aircraft structure and of an accelerometer for data correlation to the aircraft manoeuvres; the processed data are stored in non-volatile matrix memory, downloadable on ground using a PC based ground support equipment for post-processing analysis.

2.6 Cockpit Controls and Displays

The MB-339CD man-machine interface philosophy is based on two identical cockpits (Fig. 2) in order to allow complete monitoring by the rear seat instructor; each cockpit includes an Head-up Display and three identical and interchangeable Multifunction Displays capable to provide all the available formats under pilot's selection. The rear cockpit MFD's can operate in independent or mimic mode to enhance the student monitoring by the instructor. In the event of integrated avionics system failure, a complete set of stand-by instruments is provided in order to guarantee a get-home recovery in safe conditions; it includes: Attitude indicator, Magnetic Compass, Mach-anemometer, Altimeter, Vertical Velocity indicator.

The avionics controls are fitted mainly in the instrument panel for up-front operation: they are based on MFD softkeys and Data Entry Panel keyboard. The HOTAS concept is extensively employed, providing a configuration representative of an actual fighter aircraft.

The **Head-up Display** is composed by a Pilot Display Unit and a Data Entry Panel. The Pilot Display Unit uses dual-flay holographic combiners exhibiting excellent visibility also from the rear seat; it is a raster display whose navigation and attack symbology is generated by the Mission Processor.

The **Multifunction Displays** are "smart" active matrix full colour liquid crystal displays. They are capable to provide the displayed image using both 1553 data words or external video signals: graphic on video capability is also foreseen. The equipment includes 1553 interface, CPU, graphic processor with anti-aliasing capability, video interface and is able to provide as output a video signal of the displayed format for recording.

The MFD main characteristics are the following:

- Display area	5.1 x 3.9 inches
- Display resolution	640 x 480 pixels
- Brightness	> 500 CD/m2
- Contrast	> 5.5 : 1
- Grey scale	64
- Viewing angle	± 30° horiz., 0 to 30° vert.
- CPU	Motorola MC68332
- Memory	1.5 Mbytes FLASH, 1 Mbyte RAM, 64 Kbytes EEPROM

On the bezel of the MFD a group of 16 softkeys are fitted: 2 softkeys on the top allow presentation of the Menu selections and display brightness/contrast control, 6 softkeys on the bottom are used to select the requested format and 8 softkeys on the lateral sides provide pilot's selection according to the displayed format.
Presentation of the requested information is obtained through 12 main formats: the first six show data related to flight condition while the others provide the pilot with system status, check list and special information or procedure. The available main formats are: ADI (Attitude and Directional Indicator), HSI (Horizontal Situation Indicator), MAP, SMS (Stores Management System), SYS (information on general systems), SP (Steerpoint list), IN/GPS (inertial platform alignment and status), STATUS (avionics equipment status), Checklist, MARK, TVC (HUD Video Camera), RWR (Radar Warning Receiver).

The **HOTAS** configuration is derived from F-16 throttle and stick. The rotary controls are located in two separated control panels: the first, fitted below the central MFD, provide the Heading (**HDG**) and Course (**CRS**) set parameters while the second, installed on the right side of the instrument panel, allow the selection of Barometric Pressure set (**BARO**) and Altitude (**ALT**) for altitude alerter function.

All the rotary controls are implemented through incremental Gray encoders providing discrete signals for processing in the EDAB.

3. COTS INTEGRATION

3.1 General

The new avionics system development had the main purpose to provide the basic trainer aircraft with lead-in-fighter improved capability within specific constraints in terms defined development cycle and fixed budget.

The new operational requirements pushed the development of an integrated avionics system, in which sharing of resources and information between subsystems became dominant. This characteristic resulted in improved performance and reliability, whit reduced size, weight, power and costs.
To shorten development cycle and reduce recurring costs, several Commercial-Off-The-Shelf (COTS) solutions were investigated and adopted at three development levels: avionics system design, equipment selection and components employment.

COTS integration in a military application is not an easy task due to the typical military requirements: harsh environments, maximum performance in minimum weight, volume and power envelope, fault tolerance and long term supportability.
Where COTS solutions result unpractical, the reuse of existing military units allows to mitigate the obsolescence problem, while implementation of functions moving from hardware to computer software is extensively applied.

The purpose of this section is to provide a general overview of COTS integration through several examples taken by the MB-339CD avionics system.

3.2 Avionics System Design

In the MB-339CD avionics architecture the transfer of information from sensors to displays and from remote controls to transceivers is completely digital.
An essential feature for COTS integration in the MB-339CD aircraft was the employment of a widely used, non-proprietary standards and protocols (i.e., not forcing to use well defined interfaces for the electronic equipment).
In order to provide high flexibility in equipment selection, several types of standards were adopted:

- MIL-STD-1553B is applicable to the main avionics data bus;

- ARINC-429 is used to interface several navigation equipment like VOR/ILS and ADF;

- EIA Standard RS-422 allows the point-to-point data transfer from SAU to CSMU;

- EIA Standard RS-485 is used to multiplexing the information between control panels, transceivers/ transponder and remote display units.

Thanks to the implemented protocols, the industry standard RS-485 reached performances equivalent to MIL-STD-1553B at lower hardware cost.
Specific functions, which in the past required dedicated hardware resources, were implemented via software. Some examples of these functions are listed below:

- the Flight Director, that was originally a stand-alone analog computer, was replaced by a software module running in the Mission Processor;
- navigation sources and modes selection, which previously requested dedicated cockpit control panels, were provided by the MFD's softkeys through format dependent labels;

- weapon selection and monitoring, originally implemented through a dedicated armament control panel, was provided by the SMS format in the Multifunction Display;

- specific devices like altitude/airspeed switches or dedicated engine throttle position microswitches were replaced by software controlled functions using shared information.

Furthermore, the MB-339CD avionics architecture allows for future implementation of new functions, simplified by the software on-board loading capability of the main avionics equipment (i.e., MP, MFD, EGI and EDAB).

3.3 Equipment

One of the driving criteria in the selection of the equipment integrated in the aircraft was the use of COTS units and, when this aim did not allow to comply with the operational requirements or military environmental constraints, the reuse of existing military off-the-shelf equipment. The development of customised equipment was therefore limited to those applications that required specific aircraft-dependent interfaces or with particular space constraints.

Customisation of existing equipment became a possible solution thanks to the capability of autonomously developing embedded application software modules, capable to meet system integration requirements.

Examples of COTS equipment included the VOR/ILS/MB navigation receiver and the ADF: they were general aviation units that were integrated using ARINC-429 interface in the Mission Processor (installed in the aircraft with specifically designed mounting trays to cover the vibration envelope).

The areas where reuse of existing units have been applied, are the following:

- Navigation sensors like TACAN, Air Data Computer and Radar Altimeter;

- Central processing equipment as the Mission Processor and the Data Transfer System/Digital Map Generator;

- Recording units like Video Recorder;

- Cockpit displays, including HUD and MFD.

The systems customised by application software were the EGI, the MP and the FDR; the EGI and the MP were controlled by an operational software specifically developed for the avionics system, while the FDR software was updated to meet the MB-339CD application-dependent interface requirements.

3.4 Components

At hardware level, the MB-339CD avionics showed that the most important goals of a military aircraft development program (i.e., growth potential of computing resources and reduction of size, weight and power), are conveniently achieved by employing electronic components and circuits derived by commercial and industrial applications.

COTS components were selected on the basis of technical suitability for the specific application, such as component temperature range, power and voltage rating. Furthermore, the components performance and reliability were continuously monitored through feedback to equipment manufacturers.

Several COTS component applications were adopted for the MB-339CD avionics system. These are briefly described below:

- all the equipment connected to the MIL-STD-1553 data bus used the same off-the-shelf bus transceiver chip in a configuration capable to cover both Remote Terminal and Bus Controller functions;
- all the CPUs embedded in the avionics units were COTS components with extended temperature range; no MIL-STD-1750 CPU was employed while a wide range of industrial CPU were used including: Motorola microcontroller 68332, Intel microprocessors 80960, 80C186, 80C196 and 80C51, Texas Instrument digital signal processor TMS 320C3X;
- the removable cartridge of the DTS included COTS solid state Flash memory with PCMCIA interface;
- the active matrix colour liquid crystal display of the MFD was a COTS component exhibiting full compliance with military requirements thanks to the ruggedized design process;
- the incremental Gray encoders used for the rotary cockpit controls were COTS components selected on the basis of resolution, power supply and reliability requirements compliance.

3.5 Test and Evaluation

COTS technology was applied not only to the on-board systems but also to the test, verification and evaluation tools including laboratory test equipment, avionics Rig and Flight Test Instrumentation.
In order to mitigate the obsolescence risk, all the equipment of the MB-339 CD avionics system were individually tested for acceptance using laboratory test sets based on PC's and commercial software packages. This approach allowed verifying the functionality of the units autonomously, before performing the actual integration tests performed at the avionics Rig.

The adopted avionics Rig was capable to reproduce the aircraft interfaces, to provide the test engineer with representative cockpit and man-machine interface, and to simulate real dynamic flight conditions using a 3-D flight simulator software package running on a PC.

The avionics Rig was used not only for testing and verification purposes, but also for pre-flight evaluation. Particularly, test pilots and engineers could evaluate the various functions of the avionics system and relevant man-machine interfaces, obtaining progressive refinement and optimisation of the various solutions and minimising costs by reducing the number of flight test sorties required.

The avionics Rig modular architecture and the extensive use of commercial hardware and software tools allowed easy implementation of the functions associated to the integration of new equipment.

Flight test activity, conducted on the prototype aircraft, was carried out by both company and Air Force test pilots to demonstrate the expected performances, functionalities and man-machine interfaces under real flight conditions. The prototype aircraft was equipped with state-of-the-art flight test instrumentation based on COTS acquisition and recording systems (e.g., Differential GPS, Magnetic Recorders and Telemetry Data Link).

3.6 Certification and Logistics Support

COTS integration demonstrated important benefits during the system life cycle and specific advantages in certification and product support. In fact, the certification process did not address individual COTS components, modules or subassemblies, as it was aimed at specific equipment functions. However, equipment certification credit was gained by establishing that the various components were selected on the basis of proven technical suitability for the intended application (e.g., component temperature range, power or voltage rating, quality control procedures of the component manufacturer and COTS availability/implementation in similar applications). Furthermore, COTS derived products did not require additional custom engineering and support effort, because the commercial equipment manufacturers provided, as required, continuous assistance in solving obsolescence of electronic devices and circuits.

4. CONCLUSIONS

In this paper we have presented a living application of COTS equipment and components integration in a modern avionics architecture.

Particularly, we have attempted to emphasise the impact of a COTS approach on the various development phases of the MB-339CD advanced trainer aircraft.

A complete description of the new avionics has been provided and the criteria used in COTS integration have been described through several real examples covering different design areas of interest: system architecture, equipment selection and components usage.

The approach applied in the development of the MB-339CD avionics has yielded a state-of-the art and cost effective solution where the use of non-developmental equipment and COTS components has provided cost and schedule benefits reducing development risk and improving logistics supportability.

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